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TRANSIT AND RIPENING STUDIES WITH CALIFORNIA MATURE-GREEN TOMATOES

FALL 1952

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TRANSIT AND RIPENING STUDIES
WITH
CALIFORNIA MATURE-GREEN TOMATOES
FALL - 1952

A study of the effect of transit and field temperatures upon the ripening behavior of California mature-green tomatoes was continued during the fall of 1952. The results of the 1951 studies previously reported (USDA H. T. & S. Office Report No. 286 and U. of C. Veg. Crops Series No. 57) indicate the harmful role played by temperatures below 50°F maintained during transcontinental shipment. Also, mild chilling in transit becomes more harmful as the season progresses. Consequently, the problem of selecting desirable railway protective services throughout the season is important. Undesirably low transit temperatures often result from the use of too much ice, either initially or from unnecessary re-icing.

The 1951 tests show that reducing the amount of initial ice as the season progresses and the air and fruit temperatures become lower, prevents excessive cooling of the fruit in transit and aids in maintaining desired temperatures of 50 to 65°F. Furthermore, the tests show no harmful effect from having the car ventilators closed for a period of five days following the initial icing. With the vents closed, preventing the entrance of air of unknown amount and temperature, the approximate ice requirement for the proper refrigeration of tomatoes can be calculated.

One of the main purposes of the 1952 tests was to determine the transit temperatures and subsequent ripening responses of mature-green tomatoes shipped in refrigerator cars with and without ventilation.

At intervals throughout the season, pairs of cars (vented vs. non-vented) were shipped from the Tracy district to the New York market via Ogden or Salt Lake City, Utah. Each pair of cars contained test packages of tomatoes from the same field lot to determine the effect of transit temperatures and ventilation on subsequent ripening. Other lots of commercially packed tomatoes from the same district were held in California for a simulated transit period at various constant temperatures to determine the relationship between field temperatures, "transit" temperatures, and subsequent ripening.

Estimation of Ice Requirement

The cooling of a carload of tomatoes necessitated the removal of (1) the field, or sensible heat, from the fruit, boxes, and car structure; (2) the vital heat, or heat of respiration, generated by the living fruits; and (3) the heat penetrating the car when the outside temperature is higher than that in the car. An estimate of the amount of heat attributable to these sources for a closed carload of 650 boxes of tomatoes and the ice meltage needed to absorb this heat is tabulated on the following page.

Source of Heat to be Removed	Amount	Ice Requirement
Sensible Heat:		
Fruit (20,800 lbs., (specific heat = .95)	19,760 Btu	137 lbs./degree cooled
Boxes and bracing (5,500 lbs., specific heat = 0.33)	1,815 "	13 " " "
Car interior (8,820 lbs., specific heat = 0.33)	2,910 "	20 " " "
Vital Heat:		
At 80°F. (10.4 tons x 9,900 Btu/ton/day)	102,960 Btu	715 lbs./day
At 70° (10.4 tons x 7,040 Btu/ton/day	73,216 "	508 " "
At 60° (10.4 tons x 5,170 Btu/ton/day)	53,768 "	373 " "
At 50° (10.4 tons x 3,300 Btu/ton/day)	34,320 "	238 " "
Heat Penetrating from Outside (1,435 sq. ft. x .092 Btu/hr./deg. diff.)	3,168 Btu	22 lbs./day/degree differential

For example, a closed car of tomatoes cooling 25 degrees from an initial temperature of 80°F to a temperature of 55° during a three day period of hot weather (daily mean 80° outside) will require the following amount of ice:

Source of Heat	Ice Required
Fruit (137 x 25)	3,425 lbs.
Boxes and bracing (13 x 25)	325 "
Car interior (20 x 25)	500 "
Vital heat:	
First day	715 "
Second day	508 "
Third day	373 "
Heat penetrating the car (22 x 25 x 3)	1,650 "
TOTAL	7,496 lbs.

The initial ice requirements for shipments of different initial temperatures are given below. These calculations assume the load is to be cooled to 55°F and that hot weather of 80° mean temperature is encountered the first three days. Ventilators would of course have to be closed to take full advantage of the ice.

Initial Fruit Temperature	Initial Ice Required
80 - 85°F	7500 - 8600 lbs.
75 - 80°	6500 - 7500 "
70 - 75°	5500 - 6500 "
65 - 70°	4500 - 5500 "
60 - 65°	3000 - 4500 "

After the load has been cooled to 55°F, the ice requirement for holding this temperature should be very low during normal fall weather since outdoor temperatures are usually cool. The vital heat generated by the tomatoes at 55° would melt only 300 pounds of ice in a day and would be sufficient to increase the temperature of the load two to three degrees a day if no ice was available to absorb it and none of the heat generated was lost from the car.

Test Procedures

Test Cars

The test cars were standard 40 foot, end-bunker fan and non-fan refrigerators in fair to good condition. The pairs of cars shipped on each date provided some comparison of types of cars as well as comparison of protective services calling for ventilation and non-ventilation. Fan cars were used whenever available. However, most of the cars supplied for tomatoes in this district are of the non-fan type. The cars for each test were shipped from the same packing house and forwarded in the same train. Shipping and loading data appear in Tables 1 and 2.

Protective Services

The icing and ventilating procedures followed are shown in Table 1. The amount of initial ice used was reduced when the loading temperatures dropped as the season progressed. Only the cars of the first two tests were re-iced in transit. In Tests 1 to 5, inclusive, one car of each pair was shipped with ventilators closed from origin to destination. In the first three tests, the companion cars were shipped vents closed from origin to Carlin, Nevada, and with diagonal ventilation beyond. Under diagonal ventilation instructions, one ventilator at each end of the car, diagonally opposite, is open except when the outside temperature drops below 45°F. In Tests 4 and 5, one car of each pair was shipped standard ventilation, i.e., no ice and all ventilators open except when the outside temperature drops below 45°.

With Test 6, shipped November 6, both cars were forwarded vents closed, no ice, origin to destination, and with voluntary heater service (Rule 580) between Salt Lake City, Utah, and Chicago, Illinois. One automatic alcohol heater was installed in the front bunker of each car at Salt Lake City. The pilots were lighted at this point and the thermostats set to turn on the main burners at 50°F. In Car B, shipped with fans on, the front fan was turned off during heater service from Salt Lake City to Chicago.

Test Packages

A total of eight boxes of tomatoes (6 x 7 bridge-pack) from a single field lot were designated in each shipment as test packages for ripening at the market. In tests 1 to 5, two test boxes were placed in the top doorway position of the load (TD) and two near the bottom bunker (BB) in each of the paired cars. In Test 6, (heater test), single test boxes were placed at top and bottom quarterlength in both ends of each car.

Temperature Data

The temperature of the tomatoes in transit was obtained by placing small recording thermometers in the center of test packages in the top doorway and bottom bunker positions, except in Test 6 where top and bottom quarterlength positions were used. They were near the lengthwise center line of the load in all cars. Outside temperatures were obtained by attaching a recording thermometer underneath one of the cars in each test. Transit temperatures appear in Figures 1 - 6.

Icing Records

When the cars were iced to full-bunker or half-stage capacity the bunker rating was used to indicate the amount of ice supplied. The amount of ice remaining in the bunkers was estimated at Laramie, Wyoming, on the fourth day and at the market when the car was unloaded. With the exception of Car 1-B which was re-iced at Peoria, Illinois, the cars in Tests 1 and 2, shipped September 27 and October 3, were re-iced at Kansas City, Missouri. Later shipments were not re-iced in transit. The ice supply is indicated in Figures 1 to 6 showing transit temperatures.

Market Inspection

Upon arrival at the market, the test packages were inspected for color and condition (Table 3). The fruits not ripe enough for prepacking (less than firm-ripe) were held at 65°F and inspected at frequent intervals until nearly all were ripe - a period of approximately three weeks. The total percentage of ripe fruits of each lot rated for prepacking as "good", "fair", "poor", and "cull" and the classification of the defects shown by the poor and cull fruits appear in Tables 5 and 6. Fruits classed as "poor" would not be readily acceptable at retail under ordinary market conditions. The "culls" would definitely not be salable at retail.

Further data concerning the effect of transit temperature and protective service upon subsequent ripening of tomatoes were obtained by observing two portions of the commercial part of the loads during ripening at a prepacking plant. These samples consisted of 25 boxes from the top doorway position and 25 boxes from the bottom bunker position of each car in Tests 1 to 5, inclusive. The condition on arrival at the market as shown by a top layer inspection by the receiver appears in Table 4. The packout from the 25 lug samples is given in Table 7.

California Holding Tests

In order to determine the effect of pre-harvest field temperature in relation to various "transit" temperatures upon the subsequent ripening of mature-green tomatoes, five packed boxes grown near Tracy were obtained from the packing shed at approximately weekly intervals from September 25 to November 11. These were held at Davis, California, at constant temperatures of 41°, 50°, 55°, 62°, and 68°F for ten days to simulate a normal transit period to eastern markets and were then transferred to a 68° room for further ripening. As the

fruits ripened, they were classified as to quality similar to the market lots and the results are tabulated in Table 8.

Air temperatures under a shelter and ten inches above the ground level were recorded in two tomato fields in the Tracy-Carbona district. Maximum and minimum temperatures for the field near Tracy appear in Figure 7.

Results

Seasonal Weather Enroute

Weather encountered in transit by the cars of Tests 1 and 2, shipped September 27 and October 3, was warm west of Carlin, Nevada, and cool eastward. The average mean outdoor temperatures for these tests were 75° and 73°F during the first three days and 58° and 59° thereafter (Figures 1 and 2). Tests 3 and 4, shipped October 9 and 17, encountered moderate weather west of Carlin (mean temperature 64°) and cool weather beyond (mean temperatures 51° and 55°) with minima most nights below 45° (Figures 3 and 4). The records for Tests 5 and 6, shipped October 31 and November 6, show mean temperatures enroute of 52° and 50° west of Carlin and 45° and 46° eastward with many 20° to 30° nights east of Roseville, California, the first railway division point (Figures 5 and 6). On November 10, the cars in Test 6 (heater test) encountered an outside temperature of 6° near Green River, Wyoming.

Transit Temperatures

Owing to warm weather in California and high tomato temperatures normally prevailing during the early part of the shipping season, the cars in Tests 1 and 2 were initially iced to capacity to conform to the prevailing practice.

Test 1, shipped September 27, consisted of two pre-iced cars. In Car A, non-fan, pre-iced and replenished (11,500 pounds), diagonal ventilation east of Carlin, the load cooled from an initial temperature of 85° to 57°F at the top doorway position and to 46° near the bottom bunker during the five days enroute to Kansas City, Missouri, despite a period of approximately three days with diagonal ventilation (Figure 1). After re-icing this car to capacity at Kansas City, the temperatures dropped to 48° top and 40° bottom before it was unloaded five days later. In Car B -- non-operative fan equipment, pre-iced on loading day (10,500 pounds), not replenished, and forwarded vents closed to destination -- the load cooled from an initial temperature of 80° to 64° top and 46° bottom enroute to Kansas City. Although the ice bunkers were nearly empty at Laramie, Wyoming, on the fourth day, re-icing was delayed until Peoria, Illinois, on the seventh day. During the three days without ice, the temperature at the top doorway remained constant while that near the bottom bunker warmed 8 degrees to the 54° level. Re-icing this car with one ton each bunker at Peoria cooled the load to 56° top and 45° bottom during the next four days.

Both cars received more ice than necessary. More desirable bottom layer temperatures could have been obtained by omitting the re-icing in transit.

Better transit temperatures were obtained in Car B with ventilators closed and limited re-icing than in Car A with diagonal ventilation and full-bunker re-icing.

In these cars there was a spread in temperature between the top and bottom positions of the load amounting at times to 15 degrees in Car A and 20 degrees in Car B, which is to be expected in non-fan cars and fan cars shipped with fans off.

Test 2, shipped October 3, included one fan car and one non-fan car. Both were initially iced to capacity (11,500 pounds) soon after loading. In Car A, non-fan, diagonal ventilation east of Carlin, the load cooled from an initial temperature of 80° to 54°F top and 42° bottom enroute to Kansas City and continued to cool after the bunkers were re-iced to capacity at this point to minima of 47° top and 40° bottom just before arrival at the market (Figure 2). In Fan-Car B, shipped vents closed, the load cooled from an initial temperature of 78° to 46° at both positions enroute to Kansas City and dropped gradually to 42° after the car was re-iced at this point with only one ton in each bunker.

The transit temperatures in both cars were lower than desirable for tomatoes. The initial ice supplied the cars was in excess of the amount calculated for 80°F fruit and cooled the loads to points below 55° before the cars were re-iced. Both cars would have maintained temperatures well within a desirable range of 50° - 60° without re-icing in transit.

As with Test 1, the spread in temperature between top and bottom positions in the load was 15 degrees much of the time in non-fan Car A. This spread was greatly reduced in fan-Car B due to the better circulation of air through the load.

Test 3 consisted of two half-stage fan cars shipped October 9. Their rated ice capacities at the half-stage level were 6,500 pounds. They were shipped "initial ice, fans on, do not re-ice". The temperature of the tomatoes during loading was 71° to 72°F. The amount of initial ice supplied these cars was close to the calculated requirement and cooled the loads to a 50 - 55° level. Owing to the favorable weather east of Carlin, this temperature was maintained in ventilated Car A after the ice was melted (Figure 3). In Car B, with ventilators closed, the tomatoes warmed up an average of 9 degrees during the eight days following depletion of the ice supply. Both protective services resulted in satisfactory temperatures in transit and in a uniform temperature throughout the loads.

Test 4, shipped October 17, consisted of two fan cars with Car A shipped standard ventilation, no ice, and Car B. shipped initial ice one ton each bunker, do not re-ice, vents closed origin to destination. Since Car B was equipped with half-stage icing racks, they were used to keep the ice above the floor level. The initial temperature of the tomatoes was 63° to 66°F. Favorable weather in transit resulted in desirable temperatures between 55° and 60° throughout the load in Car A with standard ventilation and no ice (Figure 4). In Car B, vents closed, the initial ice cooled the load approximately 10 de-

grees in 2 days. The warm-up during the remaining six and one-half days enroute to Jersey City was 12°. Desirable transit temperatures were obtained in both cars.

Test 5, shipped October 31, compared standard ventilation and no ice (Car A) with vents closed and limited initial ice (Car B). Both were non-fan cars. The protective services were essentially the same as those used in Test 4 with fan cars. Owing to the presence of some "old ice" in Car B, amounting to approximately 1/2 ton per bunker remaining from a previous trip, no ice was added at the shipping point. Starting with 65°F fruit, the load in Car A with standard ventilation cooled to between 55° and 60° enroute to Kansas City and remained at this temperature for the rest of the trip (Figure 5). In Car B, shipped vents closed and with a small amount of ice in the bunkers, the load cooled from an initial temperature of 65° to minima of 62° top and 51° bottom before the ice was completely melted. During the next 4 days without ice, the temperature increased 4 degrees in the top doorway position and 9 degrees near the bottom bunker before leveling off for the remainder of the trip. Desirable temperatures were obtained in both cars.

Test 6 was a heater test, shipped November 6, near the end of the season and consisted of one non-fan car and one fan car. Both cars were forwarded vents closed, no ice, origin to destination, with heater service between Salt Lake City and Chicago. The initial temperature of the fruit was 57° to 60°F. By the time the heaters were installed at Salt Lake City on the third day, commodity temperatures were 66° top and 60° bottom in non-fan Car A and 67° top and 64° bottom in fan Car B, (Figure 6). Between Salt Lake City and Chicago there was slight cooling of the bottom layer in non-fan Car A but otherwise little change occurred in either car despite outside temperatures well below freezing at night. Apparently, temperatures above the thermostat setting were obtained without activating the main burners. Only slight cooling occurred between Chicago and New York City following removal of the heaters. Except in the bottom layer of non-fan Car A, the transit temperatures obtained in these cars were slightly higher than desirable. In fan Car B, the circulation of air from one fan was sufficient to maintain a uniform temperature throughout the load during the time heater service was used.

Condition on Arrival

Test boxes: The test samples from Tests 1 to 5, shipped September 27 to October 31, arrived in good condition with not over 2 per cent decay (Table 3). Only one lot arrived slightly over-ripe (TD Car 5-B). In Test 6 (heater test, shipped November 6) 6 to 10 per cent decay developed in transit probably due to the lateness of the harvest season.

No evidence of suffocation or injury due to lack of ventilation in non-ventilated cars was apparent. In a test shipped October 21, in cooperation with the Pacific Fruit Express Company and accompanied by observers, air samples taken at intervals in transit from cars forwarded vents closed from shipping point to destination showed maximum accumulations of carbon dioxide (CO_2) of only 1 per cent and no measurable depletion of oxygen at any point enroute (PFE Test No. 408). Some of the ethylene produced by the tomatoes

was apparently retain in the non-ventilated cars as evidenced by a slight effect upon potted field-pea seedlings, placed in the cars as "indicators" and somewhat more ripening in the test packages. No harmful effects are attributed to the fact that the cars were not vented.

There was a considerable difference in the ripening in transit of fruit in the top and bottom positions of the loads in initially iced non-fan cars and this difference was reflected by a more rapid completion of ripening at the market. The difference in ripening was not so pronounced in iced fan cars or in cars shipped standard ventilation without ice owing to the greater uniformity of temperature throughout the loads.

Commercial Loads: The top layer inspection of the commercial loads upon arrival at the market (Table 4) showed more ripening in transit than indicated by the test lots. However, with the exception of the cars in the heater test which arrived with 6 to 8 per cent decay, the condition of the commercial loads was satisfactory on arrival.

Effect of Transit Temperature: The ripening of the tomatoes in transit was influenced by the average temperature regardless of protective service or the position in the load. The following averages of firm-ripe, soft-ripe, and decayed fruit on arrival in the 20 test lots of Test 1 to 5, segregated according to average temperatures in transit, and the pack-out at the first sorting of commercial fruit of similar temperature show increased ripening in transit at the higher temperatures but no excessive ripening or decay at averages as high as 61° to 62°F.

AVERAGE TEMPERATURE IN TRANSIT	CONDITION ON ARRIVAL					
	Test Boxes at Unloading			Commercial Load at First Sorting		Fruit Lots Inspected
	Firm-Ripe	Soft-Ripe	Decay	Pack-Out	Waste	
°F	Pct.	Pct.	Pct.	Pct.	Pct.	No.
46-48	.3	0	.3	16.7	1.3	3
51	1.5	0	0	27.0	1.0	2
55-56	2.7	0	.7	35.0	2.0	3
57-58	7.5	0	1.5	38.5	4.0	2
59-60	7.6	0	1.0	40.0	2.4	5
61-62	11.3	0	.3	44.0	2.0	3
65-66	28.0	3.0	.5	69.5	3.0	2

In the cars with heater service (Test 6) the ripening in transit of the test lots was similar to those in non-heater cars having similar average temperature. The decay that occurred in this test apparently was due to the initial condition of the fruit since many commercial shipments with heater service prior to this test were reported sound upon arrival at the market.

Total Pack-out

The subsequent ripening and pack-out of the tomatoes was not adversely affected by keeping the ventilators of the cars closed from origin to destination. The best pack-outs resulted from protective services that produced moderate temperatures in transit.

Test boxes: In the cars of Tests 1 and 2, shipped September 27 and October 3, and iced in excess of calculated requirements, only 53 to 59 per cent of the tomatoes in the test boxes from the cold bottom bunker position ripened into "good" or "fair" market quality compared with 80 to 85 per cent in three of the four top doorway lots which were considerably warmer in transit (Table 5). The top doorway lot from Car 2-B, with an average temperature in transit as low as the bottom bunker lot from Car 1-B, failed to ripen as well as the other top layer lots. The amount and type of decay that developed during ripening in the lots from the relatively cold positions indicates chilling injury which must have occurred in transit since it was too early in the season for chilling temperatures in the field. Later, with Tests 3 and 4 in which the fruit temperatures in transit did not go below 50°F in either position, the difference in ripening between the top and bottom of the loads was not so great, averaging only 5 per cent less "good" and "fair" quality fruit in the bottom bunker lots. Similar results were obtained with Test 5, shipped October 31, in which the temperature in transit was held above 50°. Although the fruit in the cars of Test 6, under heater service, shipped November 6, did not cool in transit below 50° the lot considered least desirable after ripening had the lowest average transit temperature. The possible reduction in the amount of fruit ripening with fair or better quality as the season advances and the relation of field temperature to transit temperature is discussed later under "Holding Tests".

It appears that critical grading of the "test" tomatoes during ripening reduced the pack-out of these lots in comparison with the commercial lots. However, comparisons between test lots are strictly valid. An average of 31 per cent of the test fruits were considered to be of poor quality or culls, due largely to field defects and irregular ripening (Table 6).

Commercial Loads: The total ripening room pack-out of the commercial loads ranged from 83 to 95 per cent in all cars of Tests 1 to 5 which were inspected during ripening (Table 7). The poorest pack-out was from one of the three lots of fruit having average temperatures in transit below 50°F (bottom bunker of Car 2-B).

Effect of Transit Temperature: The following comparison of transit temperature (regardless of position in the load) and the total pack-out of the 20 test and commercial lots shows better pack-out and less waste as the average temperature in transit was raised from 46° - 48°F to levels between 51° and 66°.

AVERAGE TEMPERATURE IN TRANSIT	TOTAL PACK-OUT						
	Test Boxes				Commercial Loads		Fruit Lots Inspected
	Good & Fair	Poor	Culls	Decay	Pack-out	Waste	
°F	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	No.
46-48	55.3	23.4	7.0	14.3	75.7	24.3	3
51	60.0	25.5	7.0	7.5	89.5	10.5	2
55-56	65.0	25.0	6.3	3.7	89.7	10.3	3
57-58	68.5	22.0	6.0	3.5	88.0	12.0	2
59-60	67.0	25.6	5.4	2.0	91.4	8.6	5
61-62	74.0	20.6	4.7	.7	94.0	6.0	3
65-66	82.0	16.5	.5	1.0	93.5	6.5	2

Holding Tests

Tomatoes harvested at approximately weekly intervals and placed directly at 68°F for ripening showed a decrease in the percentage that ripened into "good" fruits as the season progressed. However, the percentage judged to be marketable, when ripe, remained above 90 per cent throughout the season. The ripening behavior (Table 8) and the temperature records (Figure 7) both point to the fact that the fall of 1952 was comparatively favorable for the production of tomatoes of acceptable ripening behavior providing they received no chilling after harvest.

At each harvest, other samples were given a ten-day simulated transit period at various constant temperatures before transferring to 68°F for ripening. In every comparison, the 10 days holding at 41° resulted in the lowest percentage of marketable fruits when ripe. This effect became increasingly important as the season progressed. The simulated transit at 50° did not result in a marked reduction of marketable "ripes" until the harvest of October 28. However, the percentage of fruits judged to be "good" when ripe showed a decrease from the first harvest as a result of the 10 days at 50°. The effect of a "transit" period at 55° previous to ripening was less detrimental than exposure to 50°. There were no large or consistent differences between lots exposed to 62° and those placed directly at 68°.

An attempt was made to correlate field temperature data with the ripening ability of those fruits placed directly at 68°F. Fair correlation exists between the percentage marketable when ripe and various criteria of field chilling. This indicates that field temperatures prior to harvest determine the subsequent ripening behavior. However, to date, no one criterion has been found that is sufficiently dependable to have good prediction value. In Figure 7, the nightly hours below 50° are shown to indicate the severity of the chilling exposure.

SUMMARY

Results obtained from shipping mature-green tomatoes in refrigerator cars from the Tracy district of California to New York City via Ogden or Salt Lake City, Utah, at intervals throughout the fall shipping season show that transit temperature can be maintained at a desirable level of 50°F to 65° by reducing the amount of initial ice as the field temperature of the tomatoes drops with the advance of the season and by shipping the cars with vents closed from loading point to destination.

Shipping the cars with vents closed conserved the initial ice supply, protected the commodity from extreme outside temperatures, and had no ill effect upon the condition of the fruit on arrival at the market or during subsequent ripening. It also simplified the calculation of the amount of ice needed to cool the fruit to a desired temperature.

Early in the season, icing cars to capacity, provided more ice than the calculated amount for cooling the fruit to 55°F, and resulted in average temperatures lower than this before the initial ice was melted. Re-icing these cars in transit resulted in undesirably low temperatures for tomatoes.

Later in the season, cars initially iced with amounts in agreement with the calculated requirement had more desirable temperatures. Cars were shipped "half-stage initial ice, do not re-ice, vents closed origin to destination" as early as October 9 when the loading temperature of the tomatoes was 70° to 73°F. Later, with 65° fruit, initial ice of 1/2 to 1 ton per bunker, no re-icing, and vents closed origin to destination provided adequate protection.

The "warm-up" of the fruit in iced cars after the initial ice supply was melted amounted to less than 2 degrees a day with car ventilators closed. Consequently, re-icing the cars should be necessary only during unseasonably warm weather. If the weather warrants re-icing the cars in transit, a supply of 1 ton each bunker on the 5th or 6th day appears to be adequate.

During cool weather, shipping the cars vents closed and with a small amount of initial ice was as effective as standard ventilation and eliminated the necessity of manipulating the car ventilators in transit.

Voluntary heater service recently made available to tomato shippers during freezing weather was successful with many commercial shipments. With test cars shipped vents closed, no ice and with heater service between Salt Lake City and Chicago, the temperature of the fruit increased an average of 5 degrees during 3 days enroute to Salt Lake City, and remained with little change after the heaters were installed.

Fan cars produced more uniform temperatures throughout the loads and were preferable to non-fan cars for all types of protective services used in the tests.

The penalty of over-refrigerating mature-green tomatoes in transit is slow ripening and reduced pack-out of good grade fruit at the market.

Holding tests using simulated transit conditions to determine the effect of pre-harvest field and post-harvest transit temperature on the ripening of mature-green tomatoes showed that a temperature of 41°F for ten days reduced the percentage of good quality fruit early in the fall season, and later temperatures as high as 50° and 55° were detrimental. These results are in general agreement with the ripening of the test samples at the market and the pack-out of the commercial fruit contained in the shipping tests.

Fruits harvested late in the season failed to ripen as satisfactorily as earlier harvested fruits. Low temperatures in the field seem to predispose the fruits to poor ripening and increased susceptibility to chilling after harvest.

Thus, the desirability of moderate transit temperatures (above 50°F), especially late in the fall season, is apparent. Methods of obtaining desirable transit temperatures, using protective services now available, are indicated.

TABLE 1. PROTECTIVE SERVICES OF TEST CARS
Tomato shipping tests from the Tracy district of California
to New York City (via Ogden or Salt Lake City, Utah), Fall 1952.

Test Car	Date Shipped	Fan Operation	Initial Icing[1]	Re-icing	Ventilating Instructions[2]
1-A	Sept. 27	Non-Fan	Pre-iced 9/26-Full Bunkers Replenished 9/27-Brentwood, Calif.	Full bunkers-Kansas City, Mo.	V.C. to Carlin, Nev. V.O.D. Carlin to New York
1-B[3]	" "	Fans Off	Pre-iced 9/27-Full bunkers Brentwood, Calif.	1 ton each bunker-Peoria, Ill.	V.C.Brentwood to New York
2-A	Oct. 3	Non-Fan	Full bunkers-Tracy, Calif.	Full bunkers-Kansas City, Mo.	V.C. to Carlin, Nev. V.O.D. Carlin to New York
2-B	" "	Fans On	Full bunker-Tracy, Calif.	1 ton each bunker-Kansas City	V.C. Tracy to New York
3-A	Oct. 9	Fans On	Half-stage-Brentwood, Calif.	None	V.C. to Carlin, Nev. V.O.D. Carlin to New York
3-B	" "	Fans On	Half-stage-Brentwood, Calif.	None	V.C. Brentwood to New York
4-A	Oct. 17	Fans On	None	None	Std. Vent. Tracy to New York
4-B	" "	Fans On	1 ton each bunker on half-stage racks-Tracy, Calif.	None	V.C. Tracy to New York
5-A	Oct. 31	Non-Fan	None	None	Std. Vent. Carbona, Calif to New York
5-B	" "	Non-Fan	1/2 ton "old ice" remaining in each bunker at Carbona	None	V.C. Carbona to New York
6-A	Nov. 6	Non-Fan	None--heater service[4]	None	V.C. Tracy to New York
6-B	" "	Fans On[5]	None--heater service[4]	None	V.C. Tracy to New York

[1] When not pre-iced, ice supplied soon after completion of loading.
[2] V.C. = Vents closed.
V.O.D. = One ventilator open each end diagonally across car. Also called Diagonal Ventilation or Special Ventilation.
Vents manipulated according to standard ventilation for tomatoes (V.C. at 45°F and below).
[3] Fan car with inoperative equipment.
[4] Voluntary heater service Salt Lake City to Chicago.
[5] Front fan turned off at Salt Lake City, turned on at Chicago.

TABLE 2. LOADING INFORMATION
Tomato shipping tests from California to New York City, Fall 1952

Test No.	1		2		3		4		5		6	
Date	Sept. 27		Oct. 3		Oct. 9		Oct. 17		Oct. 31		Nov. 6	
Shipping Point	Brentwood		Tracy		Brentwood		Tracy		Carbona		Rhodes Sta.	
Shipper	Garin Co.		Cochran Co.		Garin Co.		Cochran Co.		Louis Hayman		Cochran Co.	
Car	A	B	A	B	A	B	A	B	A	B	A	B
PFE No.	45528	28667[1]	60317	67085	47272	47352	4539	2452	45510	91040	62297	67977
Fans	None	Floor[2]	None	Floor	Floor	Floor	Floor	Floor	None	None	None	Floor
Commercial Load[3]												
Lot	a	a	4	4	a	a	5	4	b	c	14	12
Grade % U.S.#1	85	85	98	98	85	85	90	95	85	98	85	85
Brand	Garin-tee		Cock-a-too		Garin-tee		Cock-a-too		Murra		Cock-a-too	
Test Fruit[4]												
Lot	a		4		a		5		b		14	
Grade % U.S.#1	85		98		85		90		85		85	
Loading Temps. °F.												
Fruit	85	80	80	78	71	72	65	64	63	65	59	60
Air	95		95		75		80		70		75	
Field Exposure[5]												
Hrs. below 50°	0		0		8		66		178		211	

1/ ART
2/ Inoperative equipment.
3/ All loads "divided", 5 boxes crosswise of car, 5 layers high, 13 stacks in each end of load, totaling 650 lidded lug boxes. Billing weight approximately 25,000 pounds.
4/ 4 boxes, 6 x 7 "bridge pack" containing approximately 3-1/3 layers of tomatoes, in each car, same brand as commercial load.
5/ Field near Tracy.

TABLE 3. ARRIVAL CONDITION OF TEST LOTS AND TRANSIT TEMPERATURE DATA
Tomato shipping tests from California to New York City, Fall 1952

Test Car[1]	Date Loaded	Position in car	Temperature			Time to cool to 50°F	Time below 50°	Time in car	Condition Upon Arrival[2]				
			Loading	In-transit Min.	In-transit Ave.				Green	Turning	Firm Ripe	Soft Ripe	Decay
			°F	°F	°F	Hours	Hours	Days	Pct.	Pct.	Pct.	Pct.	Pct.
1-A	9/27	TD[3]	85	48	59	180	60	10	47	47	5	0	1
		BB	84	40	48	42	198	10	59	40	1	0	0
1-B		TD	81	56	66	--	--	11	18	61	21	0	0
		BB	80	43	51	54	168	11	55	44	1	0	0
2-A	10/3	TD	80	47	56	162	102	12	20	75	5	0	0
		BB	80	40	46	42	246	12	37	62	0	0	1
2-B		TD	76	42	51	84	204	12	30	68	2	0	0
		BB	80	42	48	54	234	12	43	57	0	0	0
3-A	10/9	TD	71	51	56	0	0	11	50	47	1	0	2
		BB	71	51	55	0	0	11	59	39	2	0	0
3-B		TD	72	54	60	0	0	11	44	49	6	0	1
		BB	71	50	58	72	0	11	45	51	3	0	1
4-A	10/17	TD	66	58	61	0	0	11	52	36	12	0	0
		BB	64	55	60	0	0	11	67	24	8	0	1
4-B		TD	64	55	62	0	0	11	43	45	11	0	1
		BB	63	50	59	48	0	11	66	24	9	0	1
5-A	10/31	TD	64	58	62	0	0	13	5	84	11	0	0
		BB	63	55	60	0	0	13	9	80	10	0	1
5-B		TD	66	62	65	0	0	12	0	58	35	6	1
		BB	63	51	57	0	0	12	4	82	12	0	2
6-A	11/6	TQ	60	60	64	0	0	12	4	75	15	0	6
		BQ	58	52	57	0	0	12	13	78	2	0	7
6-B		TQ	60	58	63	0	0	12	2	67	24	1	6
		BQ	59	58	62	0	0	12	3	71	16	0	10

[1] See Table 1 for protective services.
[2] Average of 2 "Bridge Pack" boxes, 6 x 7 size, containing approximately 3-1/3 layers of fruit per box.
[3] TD = Top layer at doorway; BB = Bottom layer at bunker; TQ = Top layer at quarterlength; BQ = Bottom layer at quarterlength; all near center line of car.

TABLE 4. ARRIVAL CONDITION OF COMMERCIAL LOADS IN TEST CARS
Tomato shipping tests from California to New York City, Fall 1952

Test Car[1]	Date Shipped	Temperature in Transit Ave.[2] °F.	CONDITION UPON ARRIVAL[3] Green Pct.	Turning Pct.	Firm-Ripe Pct.	Soft-Ripe Pct.	Decay Pct.
1-A	9/27	59	30	24	46	0	0
1-B		66	30	25	45	0	0
2-A	10/3	56	31	33	35	0	1
2-B		51	43	36	20	0	1
3-A	10/9	56	43	34	23	0	0
3-B		60	40	34	26	0	0
4-A	10/17	61	58	12	30	0	0
4-B		62	77	10	13	0	0
5-A	10/31	62	24	24	50	0	2
5-B		65	29	35	35	0	1
6-A	11/6	64	15	62	17	0	6
6-B		63	5	49	37	1	8

1/ See Table 1 for protective services.

2/ In top doorway position.

3/ Top-layer inspection by receiver (size of sample not known).

TABLE 5. MARKET PACK-OUT OF TEST LOTS HELD AT 65°F UNTIL FIRM-RIPE
Tomato shipping tests from California to New York City, Fall 1952

Test Car	Date Shipped	Position in Car	Average Temperature in Transit °F	QUALITY FOR PREPACKING[1] Good Pct.	Fair Pct.	Poor Pct.	Culls Pct.	Decay[2] Pct.
1-A	9/27	TD[3]	59	21	60	16	1	2
		BB	48	7	47	29	12	5
1-B	9/27	TD	66	24	61	14	1	0
		BB	51	11	42	31	12	4
2-A	10/3	TD	56	11	69	18	0	2
		BB	46	2	51	16	4	27[4]
2-B	10/3	TD	51	12	55	20	2	11[4]
		BB	48	4	55	25	5	11[4]
3-A	10/9	TD	56	7	51	29	9	4
		BB	55	7	50	28	10	5
3-B	10/9	TD	60	5	56	30	6	3
		BB	58	8	57	24	9	2
4-A	10/17	TD	61	5	64	26	5	0
		BB	60	2	54	32	11	1
4-B	10/17	TD	62	8	68	20	3	1
		BB	59	6	59	27	6	2
5-A	10/31	TD	62	7	70	16	6	1
		BB	60	7	65	23	3	2
5-B	10/31	TD	65	15	64	19	0	2
		BB	57	11	61	20	3	5
6-A	11/6	TQ	64	5	55	19	9	12[5]
		BQ	57	3	34	32	8	23[5]
6-B	11/6	TQ	63	5	55	25	7	8[5]
		BQ	62	6	48	21	10	15[5]

1/ Average of 2 lug boxes of 6 x 7 "bridge pack", averaging 138 fruits per lug.
Good and Fair = marketable at retail outlets.
Poor and Culls = unmarketable at retail outlets under most conditions.
2/ Includes decay in transit.
3/ See Table 3 for position designations.
4/ Mostly Alternaria developing in ripening room.
5/ Mostly Rhizopus developing in transit.

TABLE 6. CLASSIFICATION OF THE DEFECTS OCCURRING ON POOR AND CULL TOMATOES IN TEST BOXES[1]
Tomato shipping tests from California to New York City, Fall 1952

Test Car	Date Shipped	Mechanical Injury[2]	Field Defects[3]	Immature[4]	Irregular Ripening[5]	Total
		Pct.	Pct.	Pct.	Pct.	Pct.
1-A	9/27	5.7	14.2	0	10.4	30.3
1-B	9/27	4.0	12.9	0	12.4	29.3
2-A	10/3	2.5	7.5	0	11.5	21.5
2-B	10/3	3.0	8.1	0	17.7	28.8
3-A	10/9	3.6	8.3	1.5	26.1	39.5
3-B	10/9	3.6	10.3	1.1	20.7	35.7
4-A	10/17	8.9	11.6	1.3	15.5	37.3
4-B	10/17	10.3	9.2	.7	8.7	28.9
5-A	10/31	7.2	10.5	0	5.3	23.0
5-B	10/31	5.5	11.9	0	5.0	22.4
6-A	11/6	7.4	11.5	0	22.7	41.6
6-B	11/6	11.5	10.4	0	14.4	36.4
AVERAGE ALL CARS		6.1	10.5	.4	14.2	31.2

1/ Ave. of 4 test lugs per car.

2/ Cuts, punctures, pressure bruises.

3/ Misshapen, puff, worm damage, shoulder scars, growth cracks, sunscald.

4/ As evidenced by scuffing and shrivel.

5/ Includes 0 to .7 per cent virus mottle and waxy blister.

TABLE 7. PACK-OUT OF COMMERCIAL LOTS FROM TEST CARS AT DESTINATION[1]
Tomato shipping tests from California to New York City, Fall 1952

Test Car	Date Shipped	Position in Car	Aver. Temp. In Transit °F	ORIGINAL SORTING[2] Date	Ripe for Prepacking Pct.	Waste[3] Pct.	FINAL SORTING Date	Ripe for Prepacking Pct.	Total Waste[4] Pct.
1-A	9/27	TD	59	10/8[5]	43	3	10/23	92	8
		BB	48		13	3		87	13
1-B	9/27	TD	66	10/8	63	2	10/25	94	6
		BB	51		15	1		87	13
2-A	10/3	TD	56	10/15	45	4	10/29	87	13[3]
		BB	46		10	0		87	13[3]
2-B	10/3	TD	51	10/15	39	1	10/29	92	8[3]
		BB	48		27	1		83	17[3]
3-A	10/9	TD	56	10/20	38	1	11/3	91	9
		BB	55		22	1		91	9
3-B	10/9	TD	60	10/20	35	2	11/3	93	7
		BB	58		36	2		90	10
4-A	10/17	TD	61	10/29[5]	28	1	11/12	95	5
		BB	60		30	2		88	12
4-B	10/17	TD	62	10/29[5]	25	2	11/12	93	7
		BB	59		26	1		93	7
5-A	10/31	TD	62	11/13	79	3	11/27	94	6
		BB	60		66	4		91	9
5-B	10/31	TD	65	11/13[5]	76	4	11/27	93	7
		BB	57		41	6		86	14

[1] Each lot consisted of 25 packed boxes from either the top doorway (TD) or the bottom bunker (BB) position of the load. All percentages based on original number of fruits.
[2] On day of unloading the car unless otherwise noted.
[3] Mostly decay.
[4] Includes ripe culls unsuitable for prepacking, decay, and .1 to .4 per cent of each lot that failed to ripen before the final sorting.
[5] One day after unloading.

TABLE 8. RIPENING BEHAVIOR OF TOMATOES AT 68°F FOLLOWING A TEN-DAY SIMULATED TRANSIT PERIOD AT VARIOUS TEMPERATURES
Tomato shipping tests from California to New York City, Fall 1952

Date of Harvest and Treatment	Time below 50°F in Field	CONDITION WHEN RIPE[1]				Per cent Marketable
		Good	Fair	Poor	Culls[2]	
	Hrs.	Pct.	Pct.	Pct.	Pct.	Pct.
September 25	0					
Direct to 68°		94	3	0	3	97
10 days at 55°		86	11	0	3	97
10 days at 50°		86	9	1	4	95
10 days at 41°		71	19	6	4	90
October 2	0					
Direct to 68°		87	12	0	1	99
10 days at 62°		74	22	2	2	96
10 days at 55°		78	21	0	1	99
10 days at 50°		81	14	0	5	95
10 days at 41°		63	30	3	4	93
October 8	1					
Direct to 68°		67	30	0	3	97
10 days at 62°		64	33	1	2	97
10 days at 55°		64	33	0	3	97
10 days at 50°		69	27	1	3	96
10 days at 41°		39	44	6	11	83
October 16	66					
Direct to 68°		85	15	0	0	100
10 days at 62°		71	27	0	2	98
10 days at 55°		72	27	0	1	99
10 days at 50°		54	42	2	2	96
10 days at 41°		45	35	16	4	80
October 23	111					
Direct to 68°		54	40	0	6	94
10 days at 62°		55	40	1	4	95
10 days at 55°		25	65	4	6	90
10 days at 50°		32	62	0	6	94
10 days at 41°		29	55	4	12	84
October 28	157					
Direct to 68°		49	49	0	2	98
10 days at 62°		30	66	0	4	96
10 days at 55°		19	69	2	10	88
10 days at 50°		25	59	1	15	84
10 days at 41°		25	39	0	36	64
November 4	205					
Direct to 68°		41	53	0	6	94
10 days at 62°		47	44	0	9	91
10 days at 55°		33	44	2	20	78
10 days at 50°		38	37	1	24	75
10 days at 41°		26	36	0	38	62
November 11	251					
Direct to 68°		59	34	0	7	93
10 days at 62°		67	26	1	6	93
10 days at 55°		49	26	3	22	75
10 days at 50°		35	28	3	34	63
10 days at 41°		40	23	0	37	63

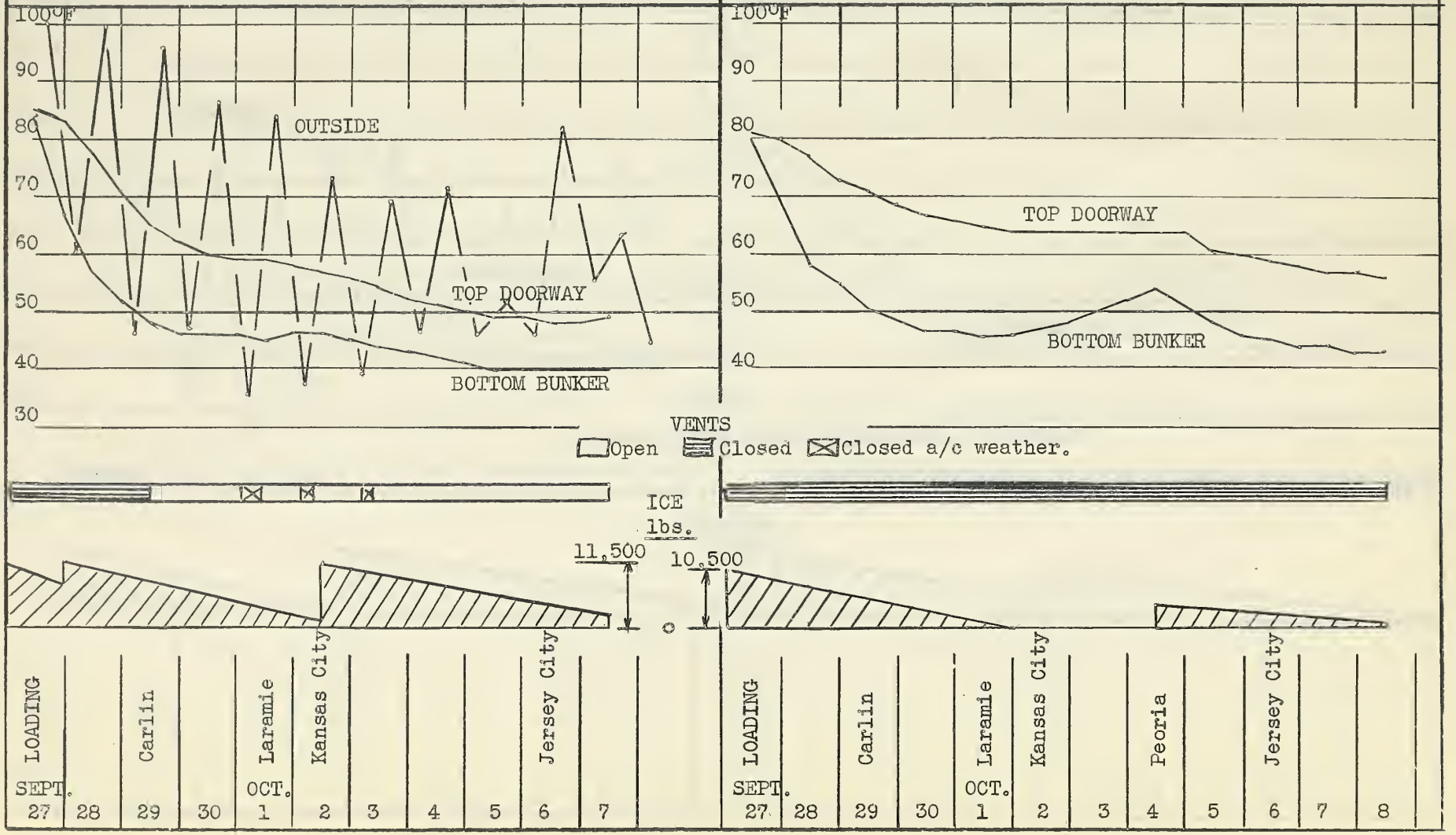
1/ One commercially packed lug per treatment; 6 x 6 pack (108 tomatoes) except harvest of October 28 which was 6 x 7 bridge pack (about 140 fruits).

2/ Unripe decayed fruits are included in culls. "Poor" and "Cull" fruit not marketable at retail under usual conditions.

FIGURE 1 - TEST 1 TEMPERATURE OF TOMATOES AND ICE MELTAGE IN REFRIGERATOR CARS, BRENTWOOD, CALIFORNIA TO NEW YORK CITY, SEPTEMBER 27, 1952.

CAR A: Non-fan. Pre-iced, replenished to capacity, Brentwood, California
Re-iced to capacity, Kansas City, Mo.
Vents closed Brentwood to Carlin, Nevada
Diagonal ventilation thereafter.
Arrived market 10/6 - Unloaded 10/7

CAR B: Inoperative fan (Fans off)
Pre-iced to capacity Brentwood
Re-iced 1 ton each bunker, Peoria, Illinois.
Vents closed Brentwood to destination.
Arrived market 10/6 - Unloaded 10/8



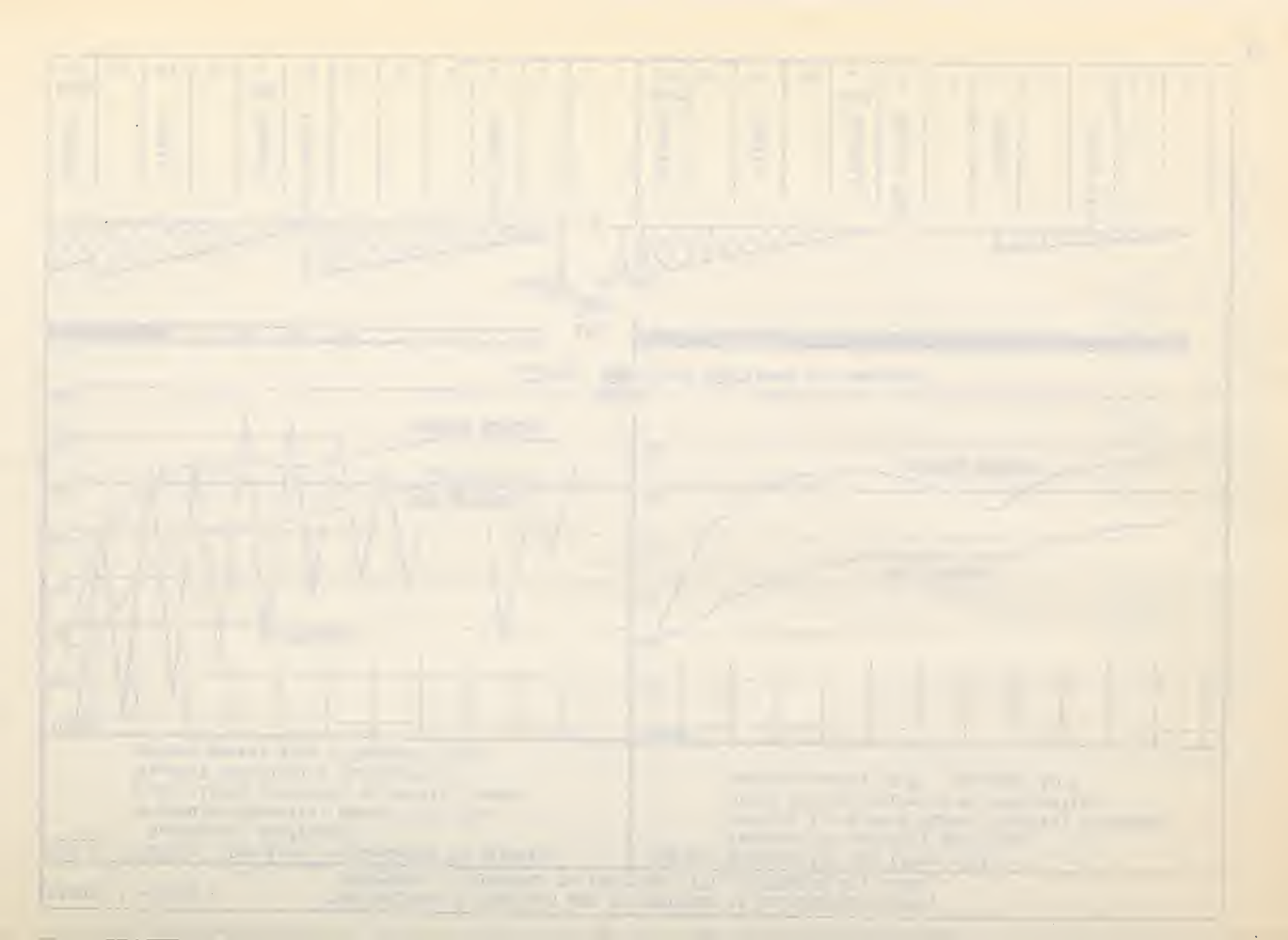
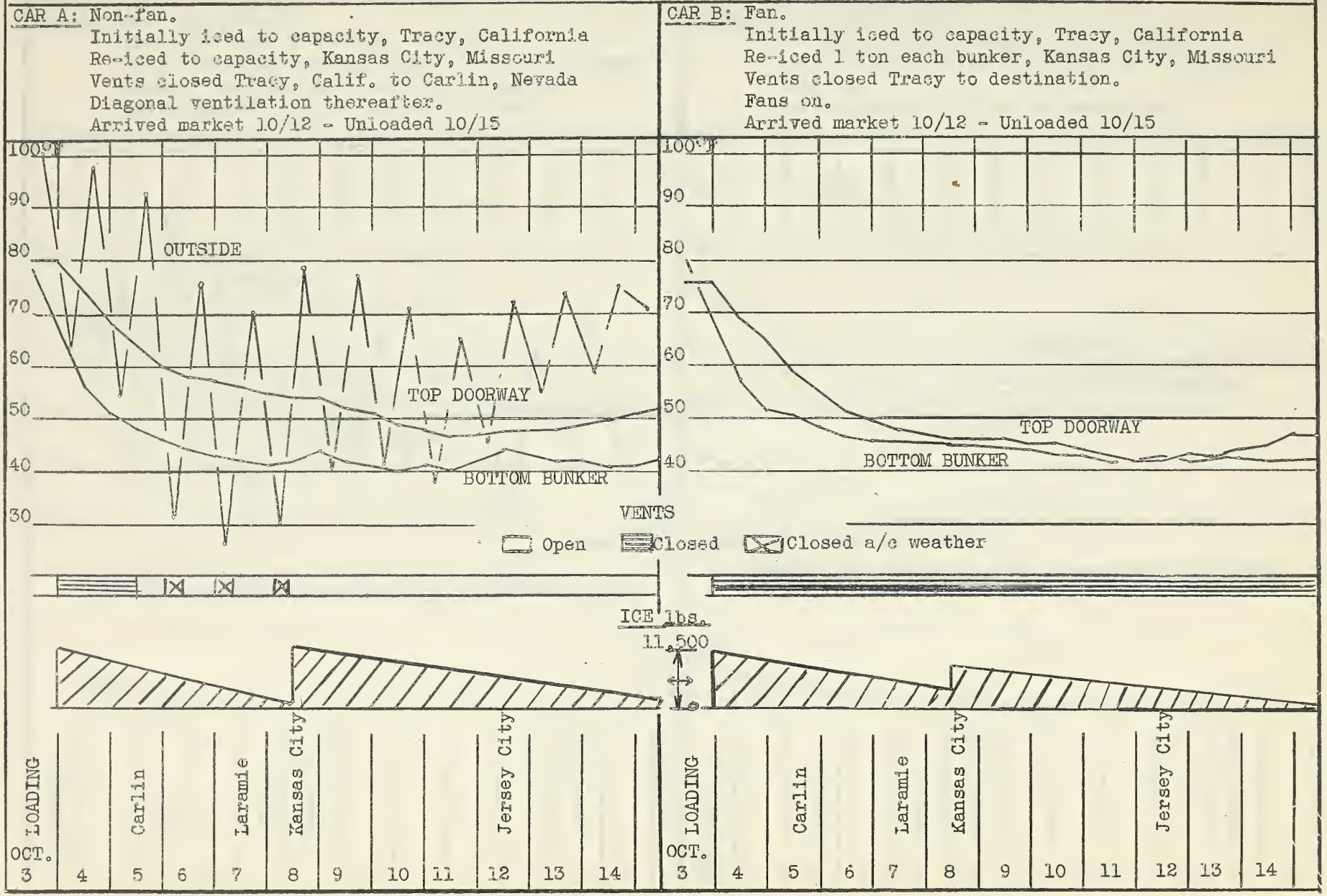


FIGURE 2 - TEST 2 TEMPERATURE OF TOMATOES AND ICE MELTAGE IN REFRIGERATOR CARS, TRACY, CALIFORNIA, TO NEW YORK CITY, OCTOBER 3, 1952.



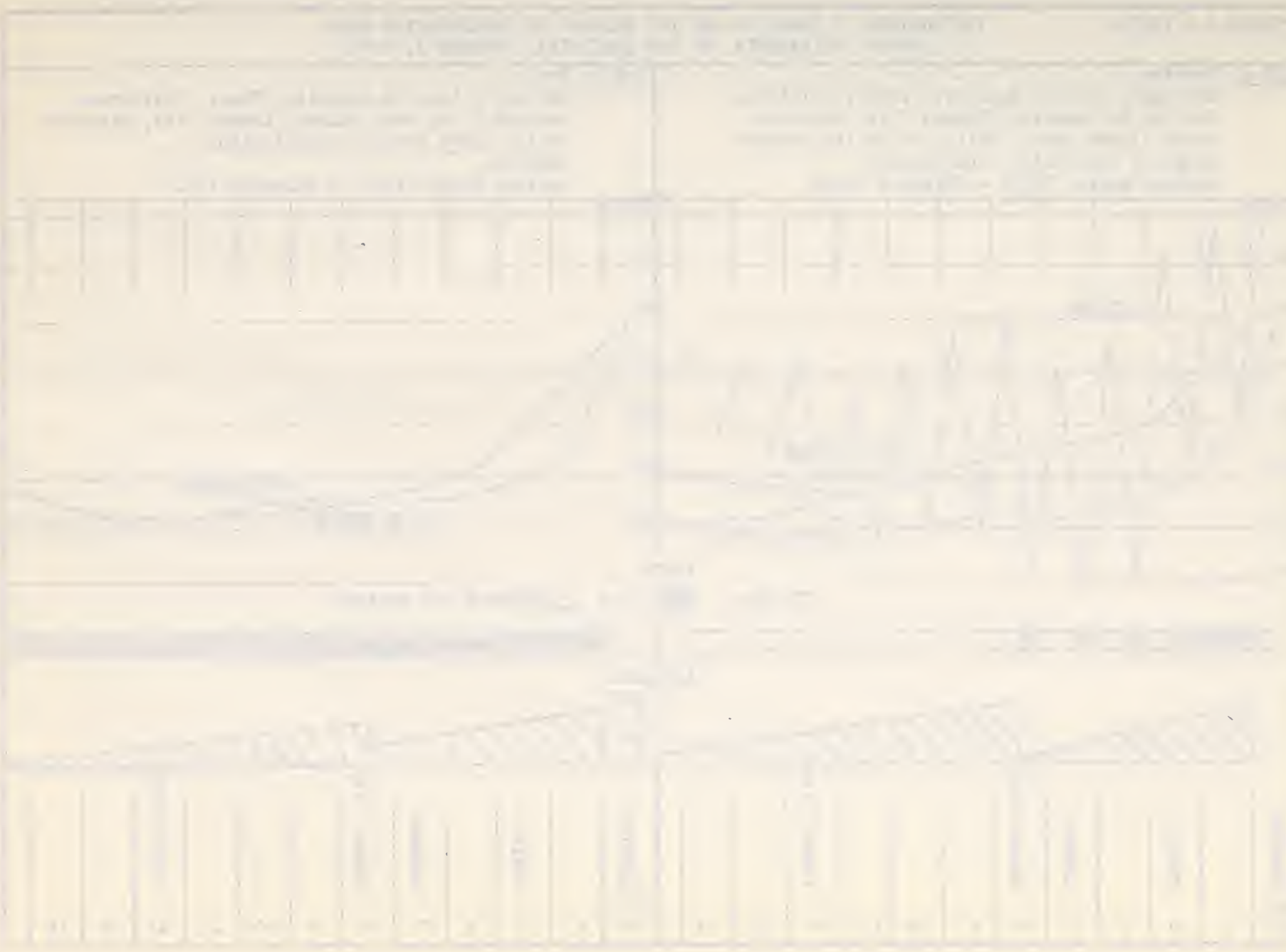
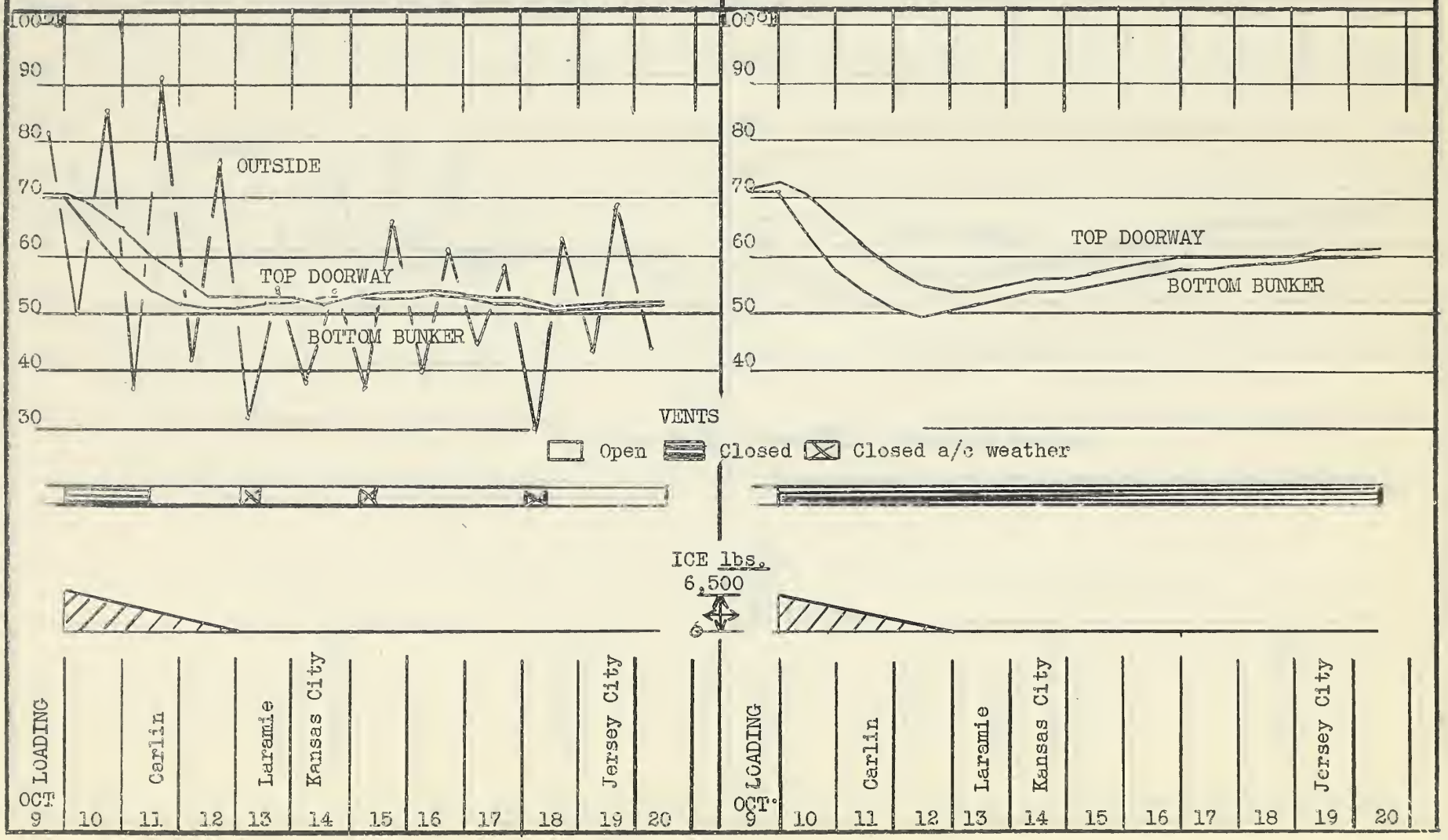


FIGURE 3 - TEST 3 TEMPERATURE OF TOMATOES AND ICE MELTAGE IN REFRIGERATOR CARS, BRENTWOOD, CALIFORNIA, TO NEW YORK CITY, OCTOBER 9, 1952.

CAR A: Fan. Half-stage.
Initially iced, Brentwood, California
Vents closed Brentwood, Calif. to Carlin, Nevada
Diagonal ventilation thereafter. Fans on.
Arrived market 10/19 - Unloaded 10/20

CAR B: Fan. Half-stage.
Initially iced, Brentwood, California
Vents closed Brentwood, Calif. to destination
Fans on.
Arrived market 10/19 - Unloaded 10/20



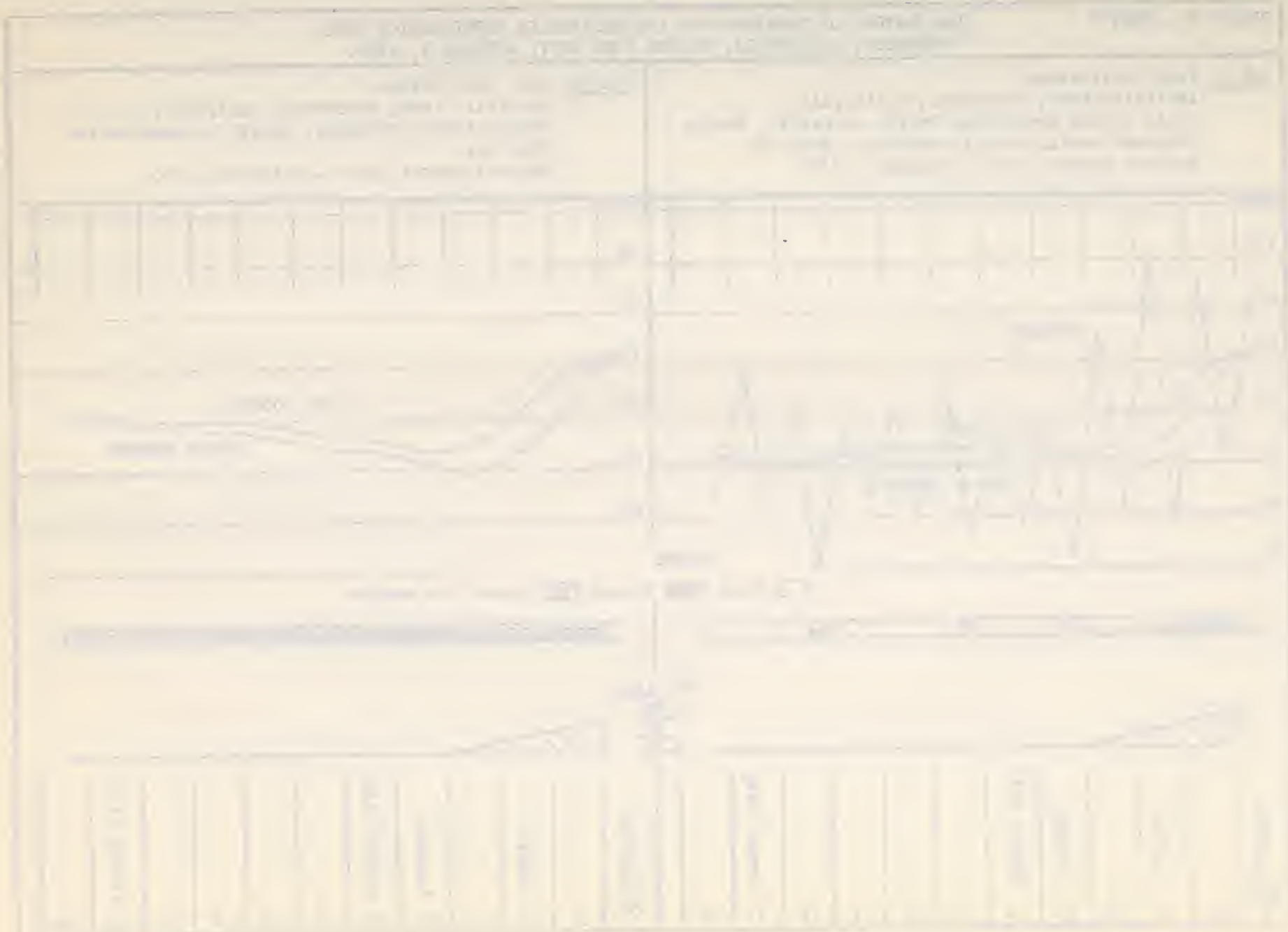
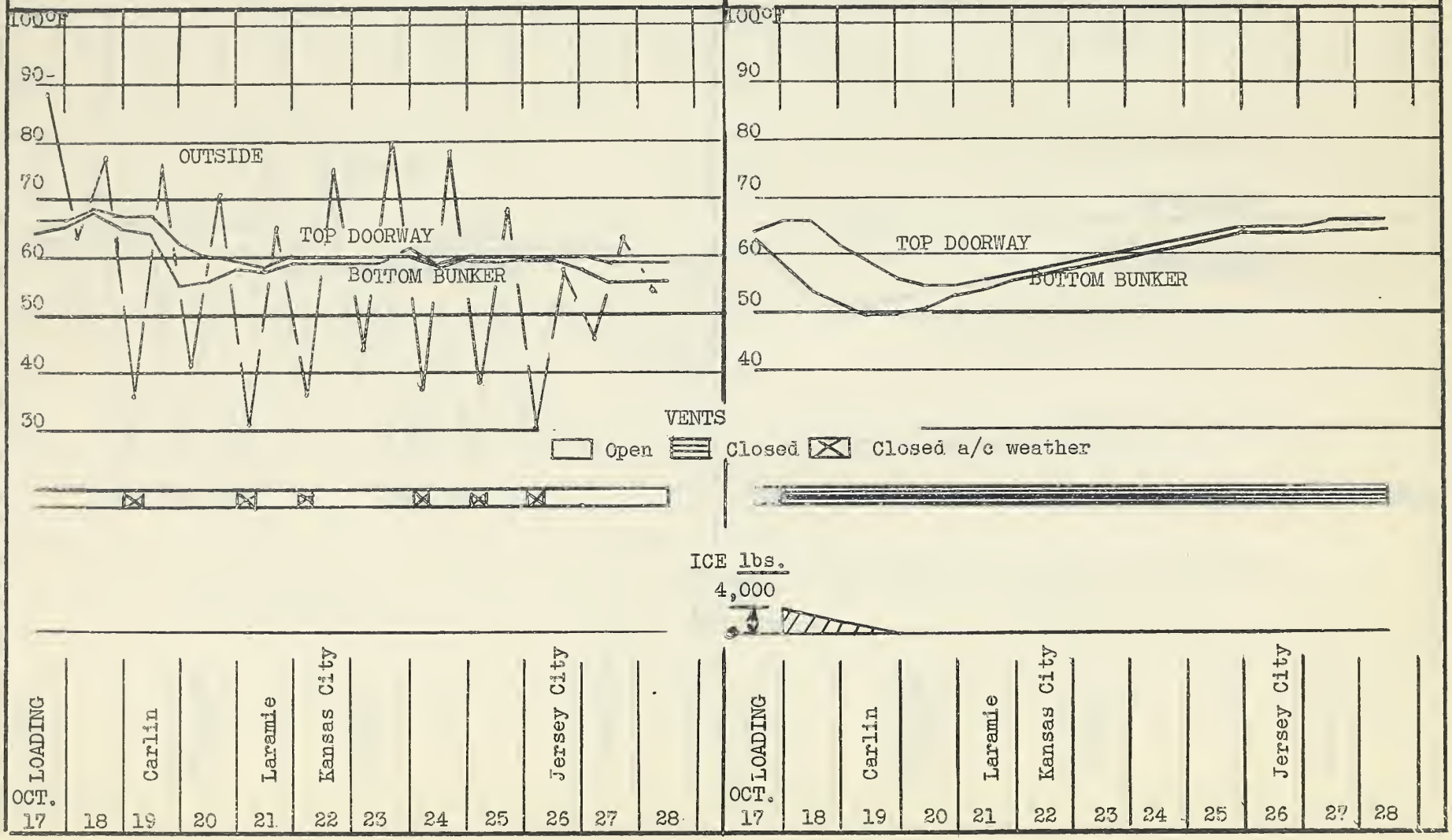


FIGURE 4 - TEST 4

TEMPERATURE OF TOMATOES AND ICE MELTAGE IN REFRIGERATOR CARS, TRACY, CALIFORNIA, TO NEW YORK CITY, OCTOBER 17, 1952.

CAR A: Fan.
Standard ventilation (no ice) Tracy, California to destination
Fans on.
Arrived market 10/26 - Unloaded 10/28

CAR B: Fan. Half-stage.
Initially iced 1 ton each bunker on half-stage racks, Tracy, California
Vents closed Tracy, California to destination.
Fans on.
Arrived market 10/26 - Unloaded 10/28



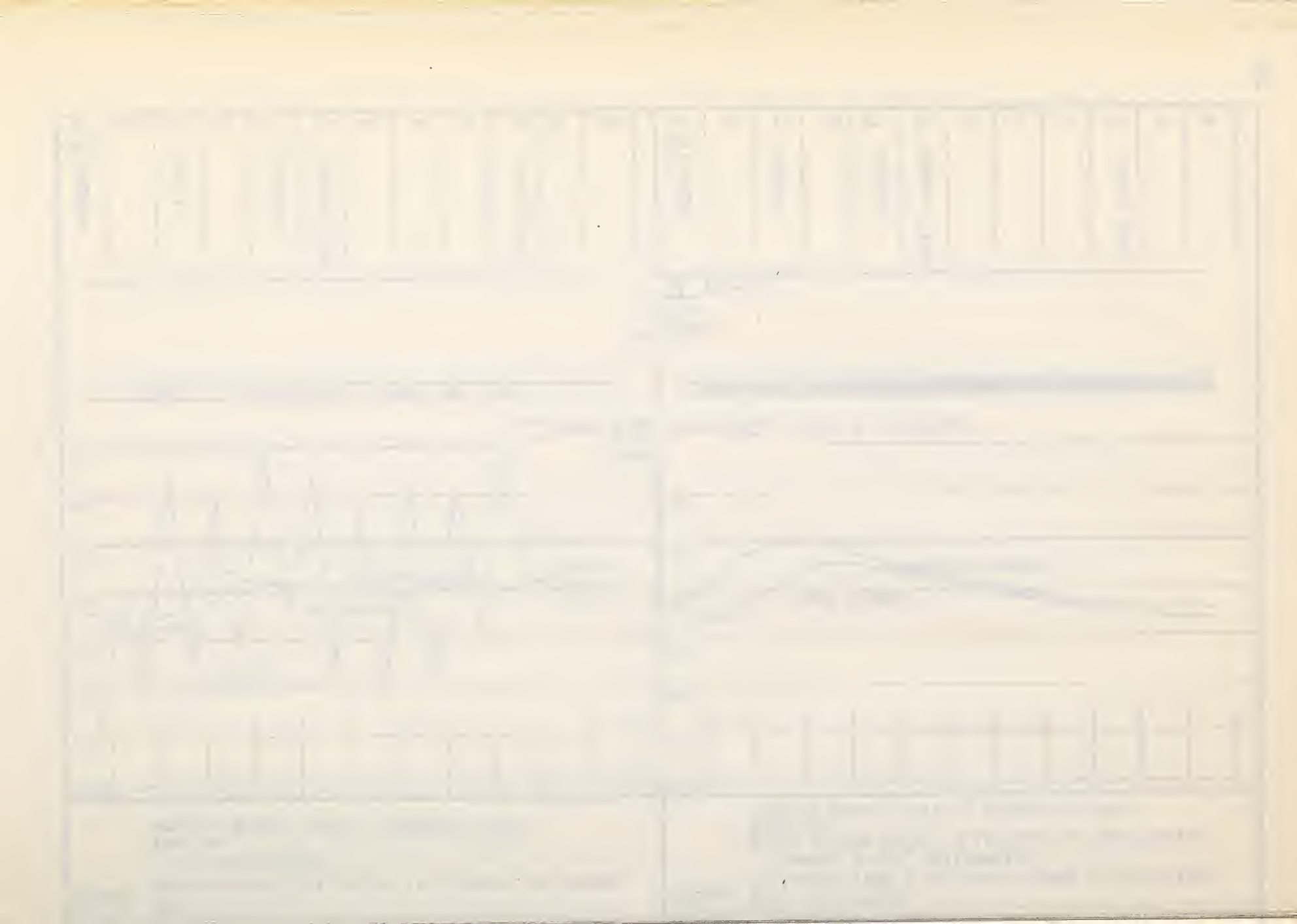


FIGURE 5 - TEST 5 TEMPERATURE OF TOMATOES AND ICE MELTAGE IN REFRIGERATOR CARS, CARBONA, CALIFORNIA, TO NEW YORK CITY, OCTOBER 31, 1952.

CAR A: Non-fan.
Standard ventilation (no ice) Carbona, California to destination.
Arrived market 11/10 - Unloaded 11/13.

CAR B: Non-fan, "ice in bunkers".
Initial ice consisting of approximately 1/2 ton of "old ice" in each bunker present at loading point.
Vents closed Carbona, California to destination.
Arrived market 11/10 - Unloaded 11/12

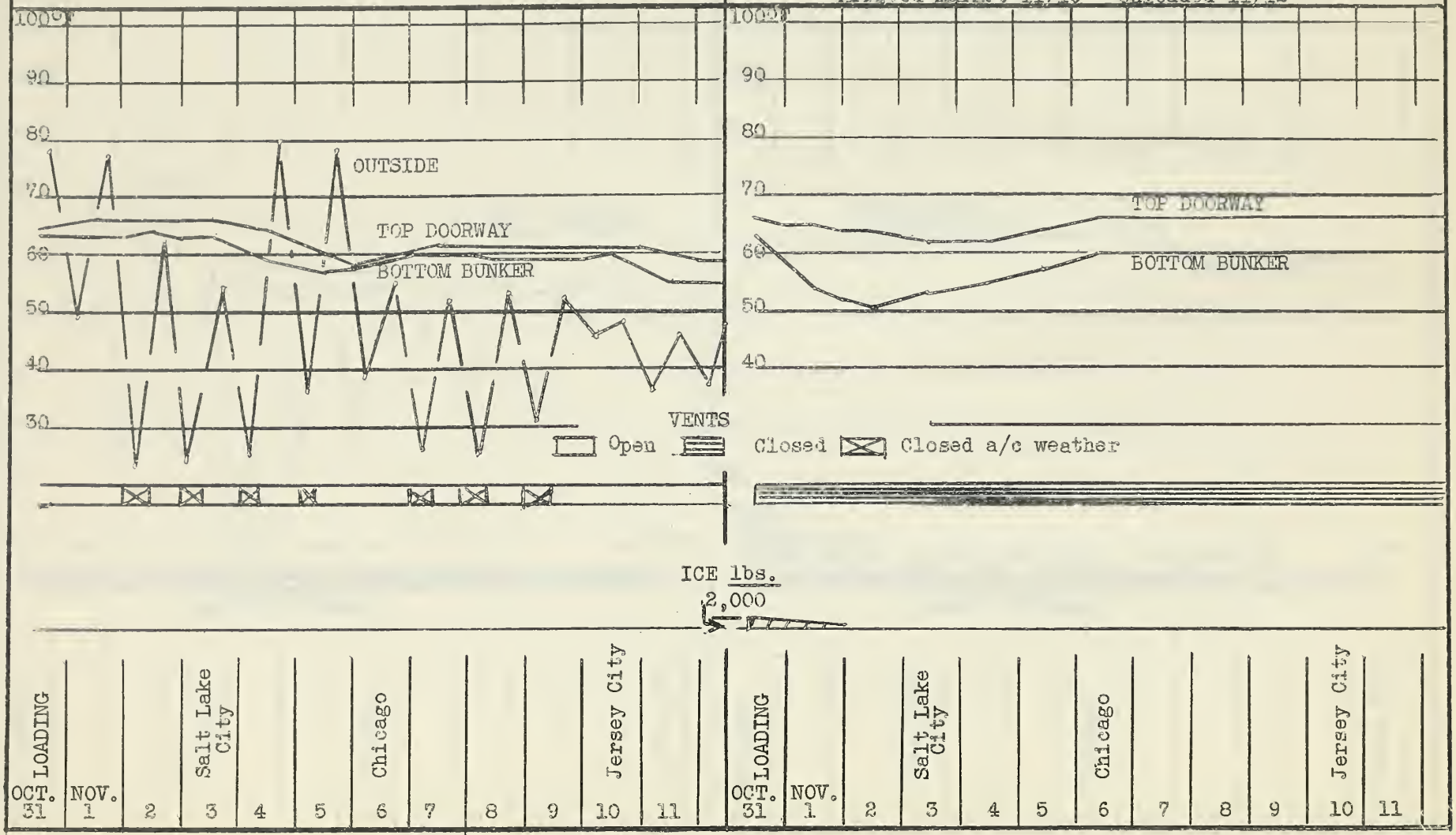


FIGURE 6 - TEST 6 TEMPERATURE OF TOMATOES IN REFRIGERATOR CARS WITH HEATER SERVICE, RHODES STATION, CALIFORNIA, TO NEW YORK CITY, NOVEMBER 6, 1952.

VENTS CLOSED, NO ICE, RHODES STATION TO DESTINATION. HEATER SERVICE (RULE 580) SALT LAKE CITY, UTAH, TO CHICAGO.

CAR A: Non-fan.
One automatic alcohol heater in front bunker.
Thermostat set at 50°F.
Arrived market 11/17 - Unloaded 11/18

CAR B: Fan.
One automatic alcohol heater in front bunker.
Thermostat set at 50°F. Front fan off during heater service.
Arrived market 11/17 - Unloaded 11/17

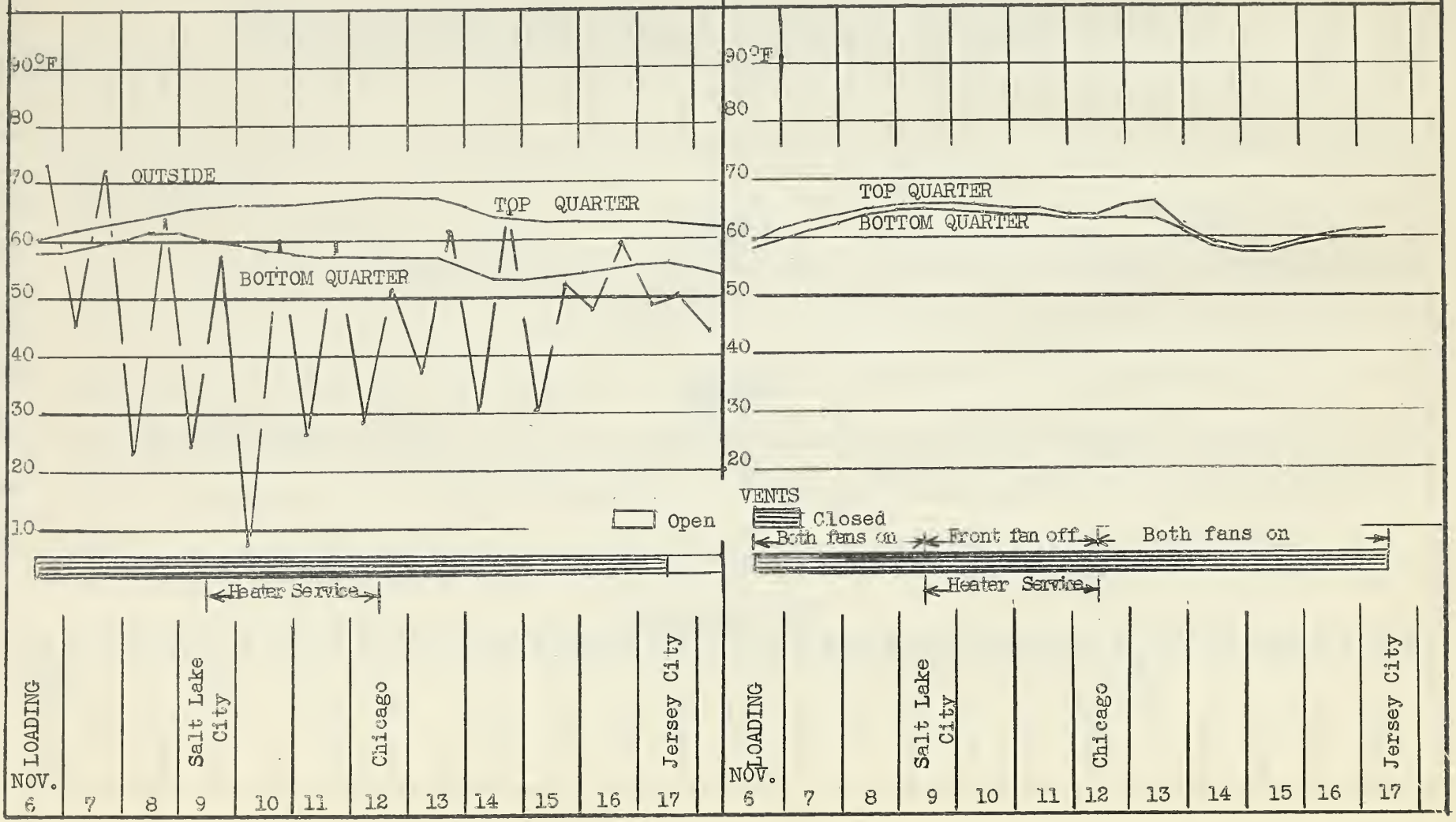
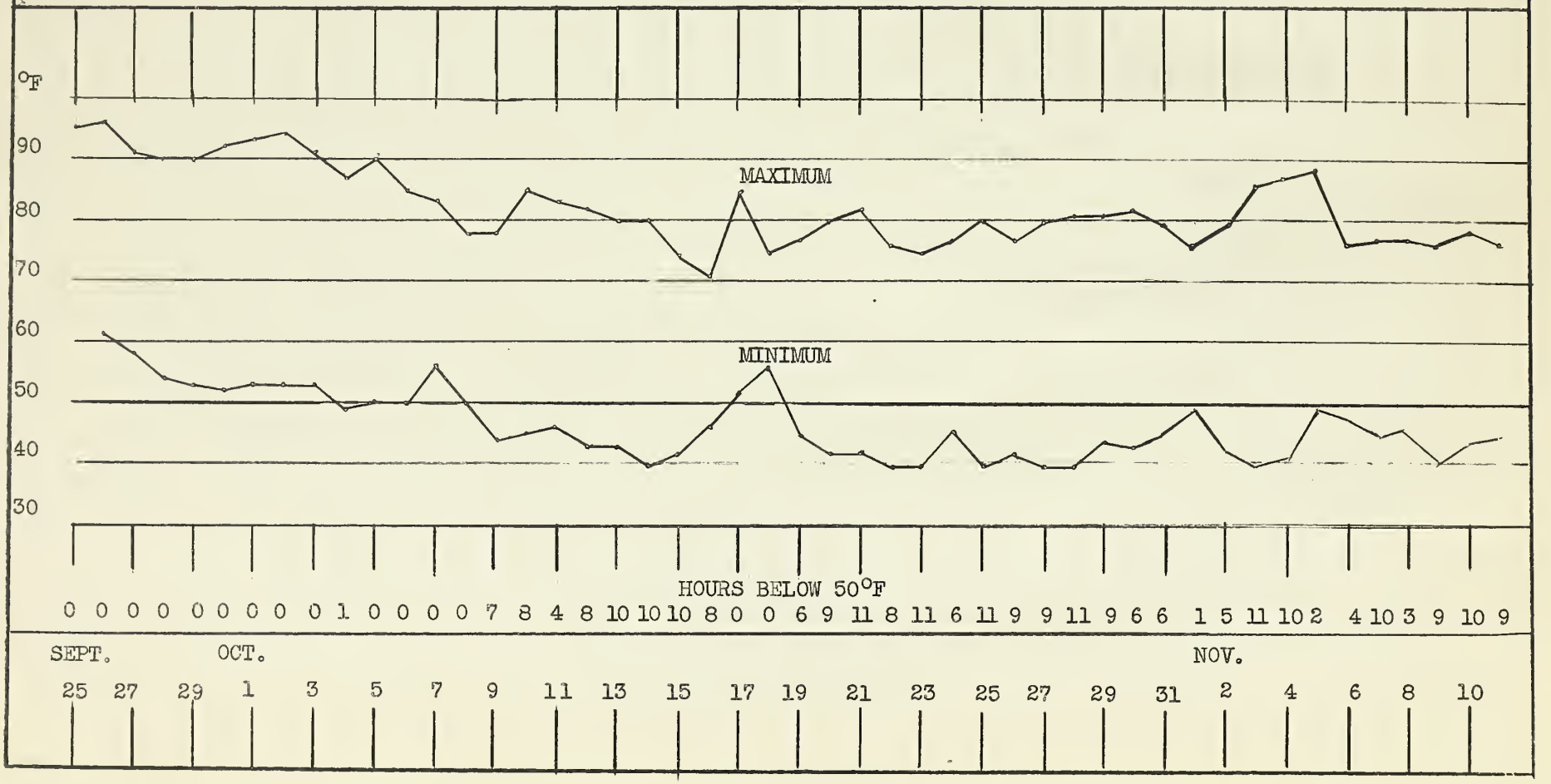


FIGURE 7

MAXIMUM AND MINIMUM AIR TEMPERATURE 10 IN. ABOVE GROUND LEVEL AND HOURS BELOW 50°F IN TOMATO FIELD NEAR TRACY, CALIFORNIA. - SEPTEMBER 25 TO NOVEMBER 11, 1952.